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(54) **SMOKE AND SOOT REMOVAL SYSTEMS FOR ADDITIVE MANUFACTURING**

(71) Applicant: **Delavan Inc.**, West Des Moines, IA (US)

(72) Inventor: **Matthew Donovan**, Ankeny, IA (US)

(73) Assignee: **Delavan Inc.**, West Des Moines, IA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 48 days.

This patent is subject to a terminal disclaimer.

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(Continued)

(56) **References Cited**

U.S. PATENT DOCUMENTS

1,908,821 A 5/1933 Cornell
4,253,224 A 3/1981 Hickman et al.
(Continued)

FOREIGN PATENT DOCUMENTS

DE 102014209161 A1 11/2015
EP 0606538 A1 7/1994
(Continued)

OTHER PUBLICATIONS

Extended European Search Report prepared, of the European Patent Office, dated Sep. 5, 2017, issued in corresponding European Patent Application No. 17166216.6.

Primary Examiner — Matthew J Daniels

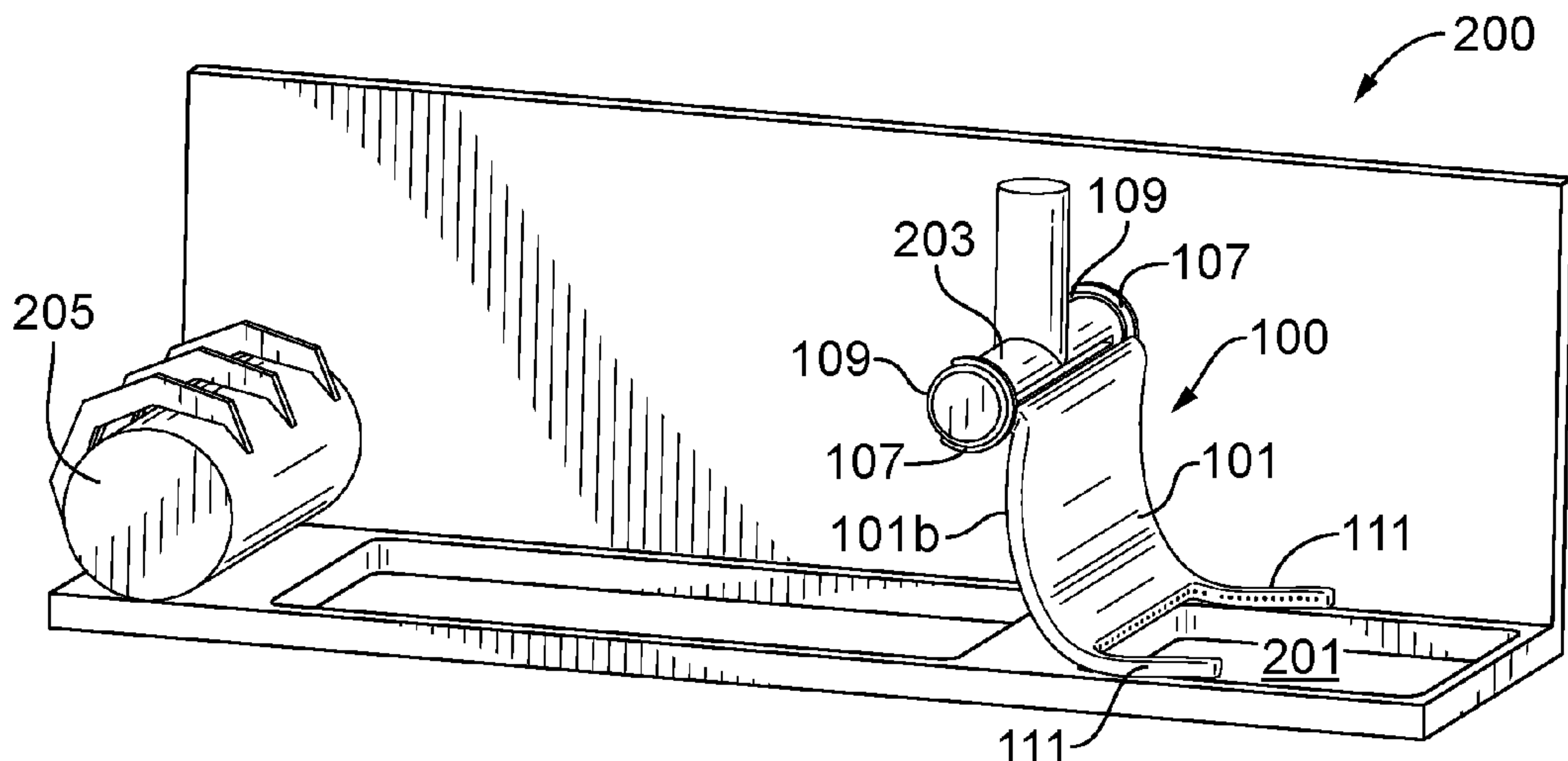
Assistant Examiner — Yunju Kim

(74) *Attorney, Agent, or Firm* — Locke Lord LLP; Daniel J. Fiorello; Gabby Gelozin

(57) **ABSTRACT**

An intake manifold for an additive manufacturing system includes a body defining a flow channel therein. The body includes an inlet end defining an inlet configured to intake gas and/or particles from a build area of the additive manufacturing system, and an outlet end defining an outlet that is fluidly connected to the inlet through the flow channel. The outlet is configured to be in fluid communication with an uptake manifold of the additive manufacturing system. The intake manifold also includes at least one mount extending from the outlet end of the body that is configured to rotatably mount the body to the uptake manifold.

14 Claims, 3 Drawing Sheets



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(2015.11)

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See application file for complete search history.

(56)

References Cited

U.S. PATENT DOCUMENTS

4,966,397 A 10/1990 McKinnon
5,336,130 A 8/1994 Ray
6,056,073 A 5/2000 Boulet
6,663,610 B1 12/2003 Thompson et al.
2008/0169586 A1 7/2008 Hull et al.
2015/0027993 A1 1/2015 Bruck et al.
2017/0072468 A1 3/2017 Schilling et al.

FOREIGN PATENT DOCUMENTS

WO 1997005421 A1 2/1997
WO 2002038033 A2 5/2002

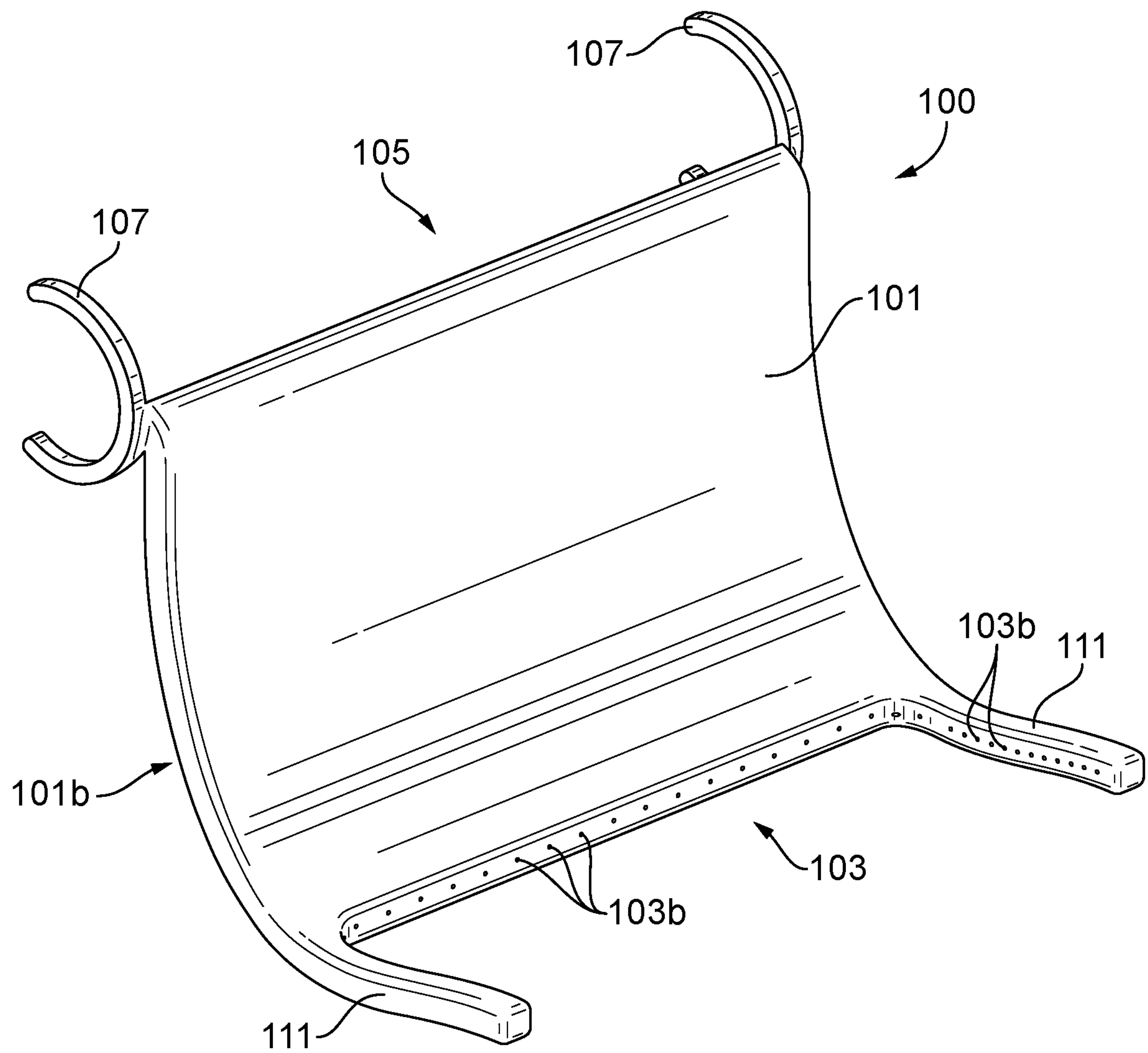


FIG. 1A

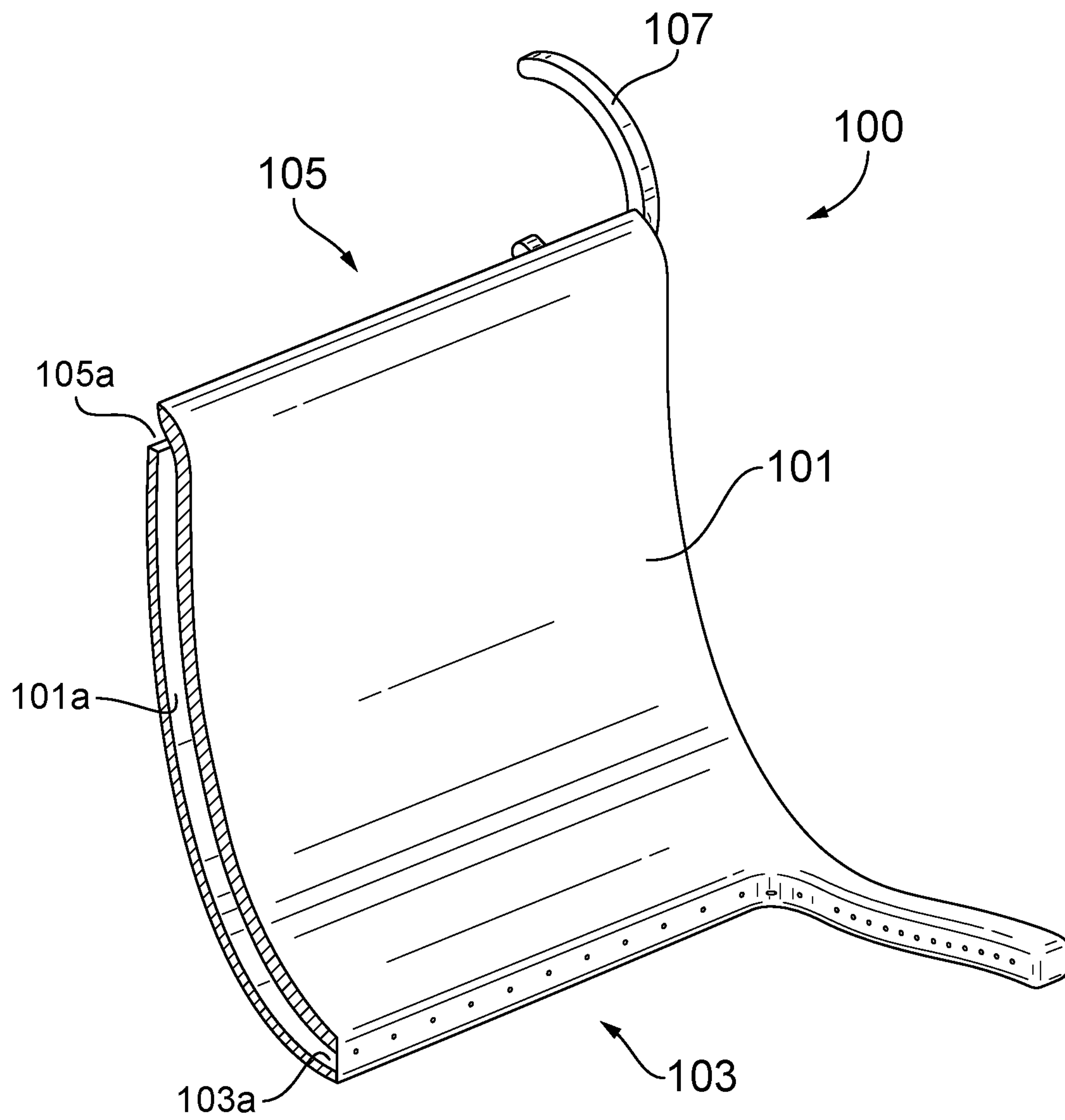


FIG. 1B

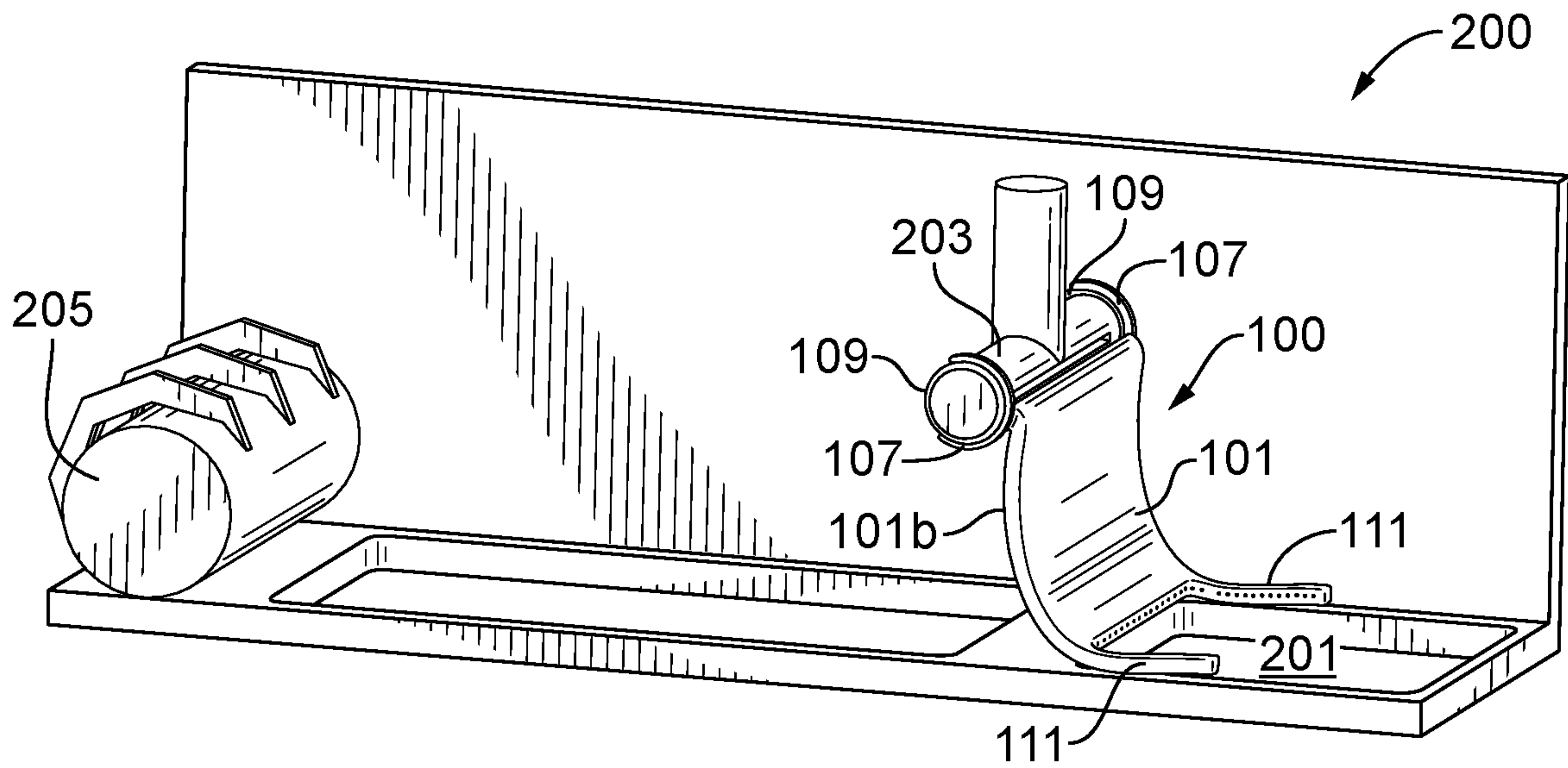


FIG. 2

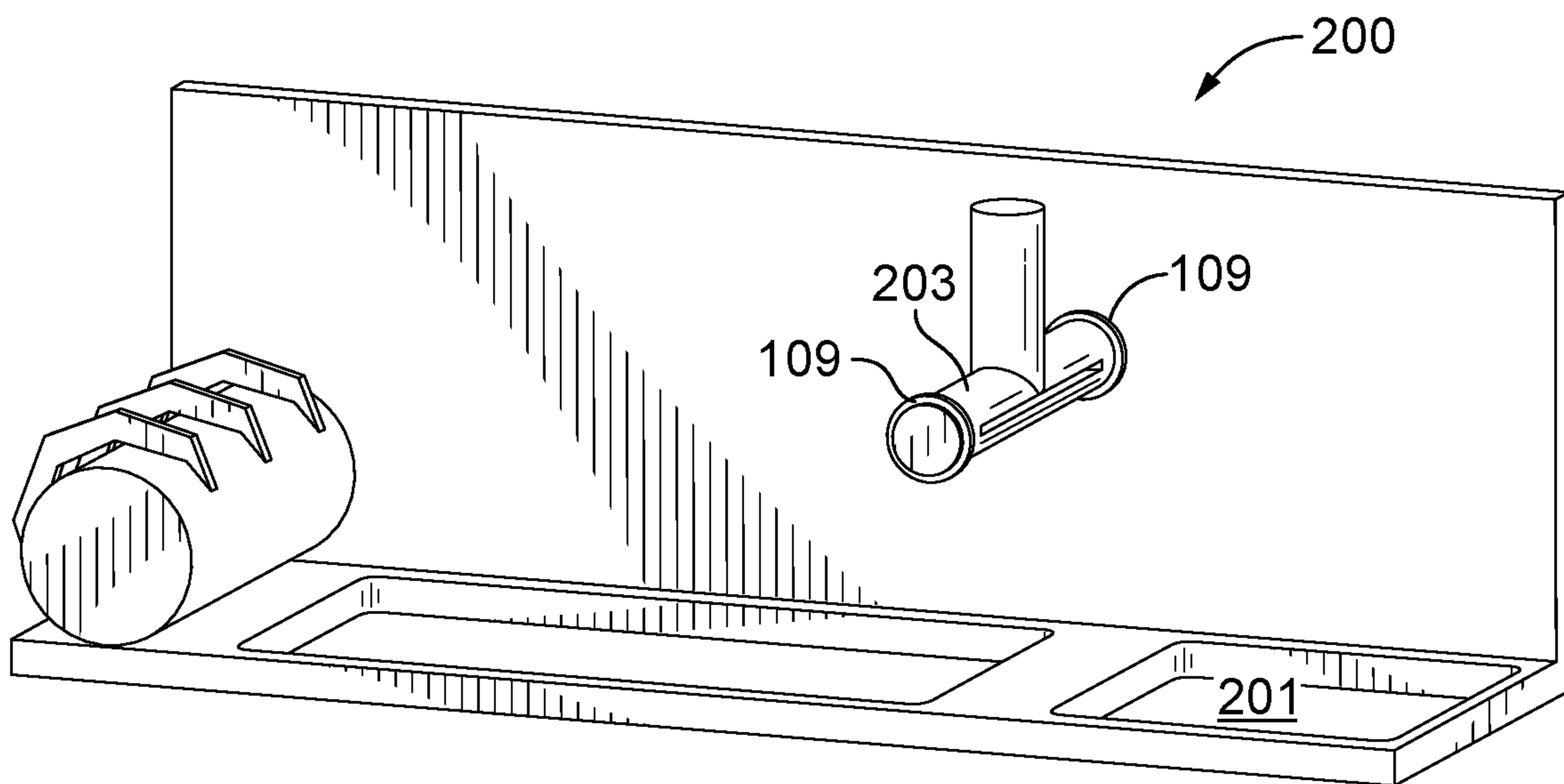


FIG. 3

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SMOKE AND SOOT REMOVAL SYSTEMS FOR ADDITIVE MANUFACTURING

CROSS-REFERENCE TO RELATED APPLICATION

This application is a divisional application of, and claims the benefit and priority of, U.S. patent application Ser. No. 15/096,340 filed on Apr. 12, 2016, the disclosure of which is incorporated by reference in its entirety.

BACKGROUND

1. Field

The present disclosure relates to additive manufacturing, more specifically to smoke and soot removal systems for additive manufacturing.

2. Description of Related Art

Certain laser based powder bed fusion additive manufacturing systems remove smoke and soot during the manufacturing process. Smoke is generated when the laser welds the powder to the previous layer. Smoke generated can cause build quality issues including failures. Traditional systems only remove smoke by using an intake pipe that is disposed several inches away from the source of smoke generation (e.g. the build area).

Such conventional methods and systems have generally been considered satisfactory for their intended purpose. However, there is still a need in the art for smoke and soot removal systems for additive manufacturing. The present disclosure provides a solution for this need.

SUMMARY

An intake manifold for an additive manufacturing system includes a body defining a flow channel therein. The body includes an inlet end defining an inlet configured to intake gas and/or particles from a build area of the additive manufacturing system, and an outlet end defining an outlet that is fluidly connected to the inlet through the flow channel. The outlet is configured to be in fluid communication with an uptake manifold of the additive manufacturing system. The intake manifold also includes at least one mount extending from the outlet end of the body that is configured to rotatably mount the body to the uptake manifold.

The at least one mount can include two mounts disposed at opposite lateral sides of the body. The two mounts can include a C-shape configured to mount to the uptake manifold. The intake manifold can include pair of bearings configured to be attached to the uptake manifold and to fit within the C-shape mounts to allow the body to rotate around the uptake manifold on the bearings. In certain embodiments, the body can include a curved shape on at least a rear face thereof for indexing against a roller of the additive manufacturing system such that the roller can push against the rear face of the body to rotate the body about the uptake manifold.

The intake manifold can include one or more border inlet arms extending from the inlet end and configured to border at least a portion of the build area to allow gas and/or particulate intake from the build area. The inlet can include a plurality of openings disposed on the inlet end and the

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border inlet arms. The intake manifold can include at least one of a polymer, ceramic, or a metal or any other suitable material.

In accordance with at least one aspect of this disclosure, an additive manufacturing system can include an uptake manifold and an intake manifold as described above rotatably connected the uptake manifold.

These and other features of the systems and methods of the subject disclosure will become more readily apparent to those skilled in the art from the following detailed description taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

So that those skilled in the art to which the subject disclosure appertains will readily understand how to make and use the devices and methods of the subject disclosure without undue experimentation, embodiments thereof will be described in detail herein below with reference to certain figures, wherein:

FIG. 1A is a perspective view of an embodiment of an intake manifold in accordance with this disclosure;

FIG. 1B is a perspective cross-sectional view of the embodiment of FIG. 1A;

FIG. 2 is a partial perspective view of an embodiment of a system in accordance with this disclosure, showing the intake manifold of FIG. 1A rotatably disposed on an uptake manifold; and

FIG. 3 is a partial perspective view of an embodiment of a system in accordance with this disclosure, showing a pair of bearings disposed on an uptake manifold.

DETAILED DESCRIPTION

Reference will now be made to the drawings wherein like reference numerals identify similar structural features or aspects of the subject disclosure. For purposes of explanation and illustration, and not limitation, an illustrative view of an embodiment of an intake manifold in accordance with the disclosure is shown in FIGS. 1A and is designated generally by reference character **100**. Other embodiments and/or aspects of this disclosure are shown in FIGS. 1B-3. The systems and methods described herein can be used to improve smoke and soot removal and improve build quality of an additive manufacturing system.

Referring to FIGS. 1A-2, an intake manifold **100** for an additive manufacturing system (e.g., system **200** as shown in FIG. 2) includes a body **101** defining a flow channel **101a** therein. The body **101** includes an inlet end **103** defining an inlet **103a** configured to intake gas and/or particles from a build area (e.g., build area **201** as shown in FIG. 2) of the additive manufacturing system. The body **101** also defines an outlet end **105** defining an outlet **105a** fluidly connected to the inlet **103a** through the flow channel **101a**.

The intake manifold **100** can include at least one of a polymer, ceramic, or a metal. Any other suitable material for the intake manifold **100** is contemplated herein.

The outlet **105a** is configured to be in fluid communication with an uptake manifold **203** of the additive manufacturing system **100** such that the uptake manifold can pull gas and/or particulate through the inlet **103a**, through the flow channel **101a**, and out through the outlet **105a**. While not shown, it is contemplated that a seal or other flexible channel can be disposed between the uptake manifold **203** and the outlet end **105**, and/or the outlet end **105** can conform to the shape of the uptake manifold **203** such that leakage between the uptake manifold **203** and the outlet end **105** is prevented.

The intake manifold **100** also includes one or more mounts **107** extending from the outlet end **105** of the body **101**. The mounts **107** are configured to rotatably mount the body **101** to the uptake manifold **203**.

In certain embodiments, as shown, the one or more mounts **107** can include two mounts **107** disposed at opposite lateral sides of the body **101**. Also as shown, the two mounts **107** can include a C-shape configured to mount to the uptake manifold **203** (e.g., which has a pipe shape). Any other suitable shape for the one or more mounts **107** is contemplated herein.

The intake manifold **100** can include one or more border inlet arms **111** extending from the inlet end **103** and configured to border at least a portion of the build area **201** to allow gas and/or particulate intake from the build area **201** around at least a portion of the perimeter of the build area **201**. In this regard, at least a portion of the arms **111** can be hollow. It is contemplated that the border inlet arms **111** can extend down an entire length of the build area **201** and/or completely surround the perimeter of the build area **201** (e.g., by forming a square frame).

As shown, the inlet **103a** can include a plurality of openings **103b** disposed on the inlet end **103** and/or the border inlet arms **111**. The openings **103b** can be of a suitable size to allow soot and smoke to be drawn through without allowing powder from the build area **201** to be pulled through. In certain embodiments, the openings **103b** can open upwardly such that gas and or particulate is pulled in from just above the build area **201** (e.g., such that a longitudinal direction of the channel through the wall defining the inlet **103a** and/or the arms **111** points at least partially upward). Any other suitable size and/or shape of the openings **103b** is contemplated herein.

Referring additionally to FIG. 3, the intake manifold **100** and/or the system **200** can include one or more bearings **109** (e.g., a pair as shown) that are configured to be attached to the uptake manifold **203** and to fit within the mounts **107** to allow the body **101** to rotate around the uptake manifold **203** on the bearings **109**. For example, the bearings **109** can be first placed on the uptake manifold **203**, and then the mounts **107** can be clips to the bearings **109**.

The bearings **109** can include any suitable type of bearing (e.g., nylon or other low friction material bushings, a ball bearing). It is contemplated that the mounts **107** can rotatably mount to the uptake manifold **203** in any other suitable manner.

In certain embodiments, the body **101** can include a curved shape on at least a rear face **101b** thereof for indexing against a roller **205** of the additive manufacturing system **200** such that the roller **205** can push against the rear face **101b** of the body **101** to rotate the body **101** about the uptake manifold **203**. For example, the roller **205** can translate across the system **200** to roll powder onto the build area **201**. The roller **205** can contact the rear face **101b** and lifts the intake manifold **100** out of the way, allowing the roller **205** to roll over the build area **201**.

As shown, the arms **111** can rest on top of the roller **205** as the roller **205** traverses the build area **201**. However, it is contemplated that the roller **205** can be configured to hold up an intake manifold **100** that does not have arms **111** (e.g., with extensions extending backward from the roller **205** to hold the intake manifold up).

As is appreciated by those skilled in the art, when the roller **205** moves out of the build area **201**, the intake manifold **100** can then fall back downward. It is contemplated that the intake manifold **100** can be electrically and/or mechanically (e.g., via a suitable motor) operated by a

controller (e.g., a CPU) of the system **200** to raise up and lower without the assistance of the roller **205**.

Embodiments as described above can dramatically improve smoke removal of the certain additive manufacturing systems (e.g., the ProX300™ system) thereby improving part build reliability and part quality. For example, certain embodiments allow smoke to be remove from two, three, and/or four sides of the build area **201**, which can significantly improving inerting atmosphere and build quality, as well as preventing particulate clouds

The methods and systems of the present disclosure, as described above and shown in the drawings, provide for additive manufacturing systems and devices with superior properties including improved gas and particulate removal/evacuation. While the apparatus and methods of the subject disclosure have been shown and described with reference to embodiments, those skilled in the art will readily appreciate that changes and/or modifications may be made thereto without departing from the spirit and scope of the subject disclosure.

What is claimed is:

1. An intake manifold for an additive manufacturing system, comprising:

a body defining a flow channel therein, the body including:

an inlet end defining an inlet configured to intake gas and/or particles from a build area of the additive manufacturing system; and

an outlet end defining an outlet that is fluidly connected to the inlet through the flow channel, the outlet configured to be in fluid communication with an uptake manifold of the additive manufacturing system;

at least one mount extending from the outlet end of the body rotatably and detachably mounted to the uptake manifold; and

one or more border inlet arms extending from the inlet end and configured to border at least a portion of the build area to allow gas and/or particulate intake from the build area.

2. The intake manifold of claim **1**, wherein the inlet includes a plurality of openings disposed on the inlet end and the border inlet arms.

3. The intake manifold of claim **1**, wherein the two mounts are disposed at opposite lateral sides of the body.

4. The intake manifold of claim **3**, wherein the two mounts include a C-shape configured to mount to the uptake manifold.

5. The intake manifold of claim **4**, further comprising pair of bearings configured to be attached to the uptake manifold and to fit within the C-shape mounts to allow the body to rotate around the uptake manifold on the bearings.

6. The intake manifold of claim **1**, wherein the body includes a curved shape on at least a rear face thereof for indexing against a roller of the additive manufacturing system such that the roller can push against the rear face of the body to rotate the body about the uptake manifold.

7. The intake manifold of claim **1**, wherein the intake manifold includes at least one of a polymer, ceramic, or a metal.

8. An additive manufacturing system, comprising: an uptake manifold;

an intake manifold including a body defining a flow channel therein, the body including:

an inlet end defining an inlet configured to intake gas and/or particles from a build area of the additive manufacturing system; and

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an outlet end defining an outlet that is fluidly connected to the inlet through the flow channel, the outlet configured to be in fluid communication with the uptake manifold of the additive manufacturing system;

at least one mount extending from the outlet end of the body and rotatably mounted to the uptake manifold; and

one or more border inlet arms extending from the inlet end and configured to border at least a portion of the build area to allow gas and/or particulate intake from the build area.

9. The additive manufacturing system of claim **8**, wherein the inlet includes a plurality of openings disposed on the inlet end and the border inlet arms.

10. The additive manufacturing system of claim **9**, wherein the two mounts are disposed at opposite lateral sides of the body.

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11. The additive manufacturing system of claim **10**, wherein the two mounts include a C-shape configured to mount to the uptake manifold.

12. The additive manufacturing system of claim **11**, further comprising pair of bearings configured to be attached to the uptake manifold and to fit within the C-shape mounts to allow the body to rotate around the uptake manifold on the bearings.

13. The additive manufacturing system of claim **8**, wherein the body includes a curved shape on at least a rear face thereof for indexing against a roller of the additive manufacturing system such that the roller can push against the rear face of the body to rotate the body about the uptake manifold.

14. The additive manufacturing system of claim **8**, wherein the intake manifold includes at least one of a polymer, ceramic, or a metal.

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